Improving E-Book Learning Experience by Learning Recommendation

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***Abstract*—Technology Enhanced Learning is one of the most dynamic areas of inquiry in education. One form of TELs, that is on-screen learning, has become the topic of interest of many works. It is popular mainly with young people despite all findings, which undoubtedly suggest that it is detrimental to learning. The method hinders learning experience due to the reading spatial instability, difficulties in establishing mental map, and poor visual ergonomics. Currently, many textbooks are available in electronic form and a majority of the students in Bina Nusantara University in Indonesia, for example, consider the form to be more convenient and preferable. In the electronic form, the textbooks are much more affordable. They can be obtained easier than the printed books. This work intends to explore a method of improving the learning quality of the electronic textbooks. The improvement is expected to be achieved by enriching the electronic textbook with cues in the form of margin notes, highlights, markers, lines and arrows, and navigation tools provided by the subject matter expert. The idea is implemented on a class at the university and its effects are assessed. The participants are divided into two groups having the same distribution of the past academic performance where one group is assigned to learn using the recommendation system and the other is without the system. After the learning, their understandings are assessed systematically by qualitative and quantitative methods. The participants with the recommendation system outperform those without significantly, which is marked by the values of the Cohen's effect size d larger than 1.20 with the standard deviation about 0.563.**

I. Introduction

This study is within the category of Technology Enhanced Learning (TEL), which has been recognized as one of the most dynamic areas of inquiry in education [1]. TEL aims to design, develop, and test socio-technical innovations that will support and enhance learning practices [2]. Specifically, TEL is about recommender systems that are designed to enhance the learning experience. For instance, a recommender system with the main task of 'annotation in context' is designed to provide learners the list of relevant learning materials for a given course [2].

Many research findings suggest that technology potentially enhances certain aspects of learning experiences. However, there are also findings suggesting otherwise that technology interferes certain aspects of learning experiences. For instance, let us consider the case of reading on a computer screen. Many aspects related to the reading on a computer screen and its effects on the cognitive process have been previously studied [3]–[6]. Some important and relevant findings are summarized the following.

Reading on the computer screen has been found having many issues. The first is that the reading process often undergoes spatial instability that primarily occurs during screen scrolling. It detrimentally affects the reader's mental representation of learning material [3]–[5]. The second issue is that difficult for a reader to establish mental map/spatial layout of text in entirety [6]. Some suggest that screen reading is better for a shallow reading of short texts and not for effortful learning such as learning a textbook [7]. The third issue is that the screen reading has poor visual ergonomic where the screen refresh rate, contrast level, and fluctuating light interfere cognitive process [8], [9].

This study is our first step to understanding whether the detrimental effects of the on-screen learning can be mitigated by using a recommender system.

TEL has been studied from various contexts including in-class learning, self-regulated learning, and collaborative learning. [10] studied the use of video game to support the teaching of Introductory Economics course and its effects on cognitive and affective aspects of the learners. In self-regulated learning, TEL provided more autonomy in learning and minimized dependency on lecturer [11]. TEL has also been used to enhance the implementations of the self-regulated learning principles: delayed meta-cognitive monitoring, content summarization, selection of review material, and practice tests [12], [13]. Generally, TEL or educational computer, in particular, was identified to be well-suited for collaborative learning [14]–[16] despite the fact that they may exhibit socio-emotional challenges due to member's backgrounds [17].

This work intends to study to what extent a system recommendation may improve the learner cognition on on-screen learning for material that requires effortful learning. Such material was identified difficult to be learned on-screen [7].

II. Research Method

The following research procedure was performed to understand how a simple learning recommendation system improves the understanding of students.

Firstly, we selected learning materials from a widely used textbook in Bina Nusantara University. The materials were Chapter 9 and Chapter 10 of the textbook of [18] and were available electronically in pdf format.

Secondly, we asked a subject matter expert to provide learning recommendations on the materials. The expert studied the materials and provided learning recommendations on the

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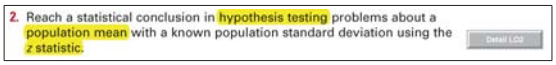
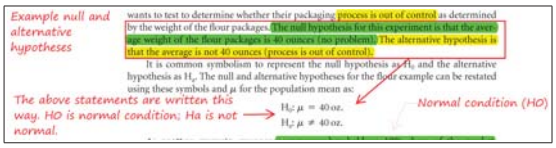
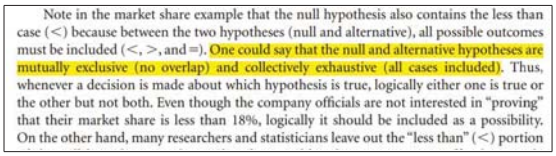


(a) The example of the learning recommendations provided by the lecturer on the electronic learning materials for the students. This figure shows the learning outcome 2 of the session where the keywords were highlighted and an interactive object, the button, was provided to bring the learner to the relevant part within the material.



(b) Another example of the provided learning recommendations: annotations, high- lights, and graphical objects were provided to explain the materials.


Note in the market share example that the null hypothesis also contains the less than case (<) because between the two hypotheses (null and alternative), all possible outcomes must be included (<, >, and =). One could say that the null and alternative hypotheses are mutually exclusive (no overlap) and collectively exhaustive (all cases included). Thus, whenever a decision is made about which hypothesis is true, logically either one is true or the other but not both. Even though the company officials are not interested in "proving" that their market share is less than 18%, logically it should be included as a possibility. On the other hand, many researchers and statisticians leave out the "less than" (<) portion

(c) A highlighted passage within the learning material that is important for students to understand the concepts of null and alternative hypotheses.

Fig. 1. The examples of the learning recommendation to improve the student learning.

electronic documents by using highlights, marginal notes, annotations, hyperlinks, and interactive objects. The recommendations were designed to help students in the following respects: minimizing the need for the screen scrolling; helping students understand the entire text organization; improving the visibility of essential keywords, sentences, and formulas; establishing connections between ideas; and strengthening important concepts.

The examples of the learning materials enriched with the learning recommendations are shown in Fig. 1. Figure 1(a) shows a case of the learning outcome 2 of the chapter, which has nine learning outcomes in total. The subject matter expert considered the keywords "hypothesis testing", "population mean", and "z statistic" to be the most important aspects of the learning outcome; thus, the expert highlighted the three keywords. To the right of the passage, a button labeled "Detail LO2" was provided that would instantly take the students to the relevant part of the text. The object allows students to see the relevant material part with a minimum screen scrolling. Figure 1(b) shows another example of the learning recommendation. The context related to this figure is about the development of null and alternative hypotheses. The annotation "Example null and alternative hypotheses" wad provided by the expert to help the students identifying the passage content. In addition, the relevant passage was framed, and an arrow was added to point to the related implication of the expression of the passage.

Two groups of students were established in this study. The participants were the 3rd-year undergraduates of the School of Business Management of Bina Nusantara University in Jakarta, Indonesia. Those students enrolled in a small special class so called the global class, where all of them were fluent in English. The university sets a certain level of English proficiency as a requirement for students to enroll in the global class. For this class type, all subjects are delivered in English and all teaching materials including textbooks, slides, assignments, and exams are also in English.

The number of participants was 18 students; 33% students were female, and the remainders were male. They were about 20 years old; the age was not systematically assessed. All were Indonesia native, and English was their second language. The students in the class were separated into two groups, matched for their academic performance. Each group had nine students.

The teaching material was provided in laptop in pdf format. All students learned the material using Adobe Acrobat Reader. The students were provided one-hour duration to learn the material. At the end, their understanding was assessed by a set of problems in multiple choices with the duration of 30 minutes. The assessment material was printed. The control group was assigned to learning materials without the learning recommendation. The treatment group was with the learning recommendation.

After learning the materials, the students were assessed for their knowledge acquisition and preference. The first aspect was evaluated quantitatively where the students were given some problems to solve. The second aspect was evaluated qualitatively via interviews. The typical quantitative assessment is reproduced in Table I. Finally, the student scores on the assessment were analyzed statistically using the Welch's t-test [19], Mann-Whitney U test [20], and the Cohen's d effect size index [21].

TABLE I
THE EXAMPLE OF THE QUANTITATIVE ASSESSMENTS FOR STUDENT UNDERSTANDING.

In an attempt to determine why customer service is important to managers in the United Kingdom, researchers surveyed managing directors of manufacturing plants in Scotland. One of the reasons proposed was that customer service is a means of retaining customers. On a scale from 1 to 5, with 1 being low and 5 being high, the survey respondents rated this reason more highly than any of the others, with a mean response of 4.30. Suppose the US researchers believe American manufacturing managers would not rate this reason as highly and conduct a hypothesis test to prove their theory. Alpha is set at .05. Data are gathered and the following results are obtained. Use these data and the eight steps of hypothesis testing to determine whether U.S. managers rate this reason significantly lower than the 4.30 mean ascertained in the United Kingdom. Assume from previous studies that the population standard deviation is 0.574. The sample data are: 3, 4, 5, 5, 4, 5, 5, 4, 4, 4, 4, 4, 4, 4, 4, 5, 4, 4, 4, 3, 4, 4, 4, 3, 5, 4, 4, 5, 4, 4, 4, 5
How many tail should be used for the test on this case? (a) 1-tail (b) 2-tail (c) Multi-tail (d) No tail
What is the value of the test statistic? (a) 1.42 (b) -1.42 (c) 1.43 (d) -1.43
Would they be able to reject the null hypothesis? (a) Yes (b) No

A. The detail of the learning materials

This subsection provides the details of the learning materials used in the study.

The utilized learning materials were Chapter 9 and Chapter 10 of the textbook of [18]. The textbook was widely used by the university. The title of Chapter 9 was "Statistical Inference: Hypothesis Testing for Single Populations". The title of Chapter 10 was "Statistical Inferences about Two Populations". These materials were provided to the students in pdf.

Briefly, the teaching materials of Chapter 9 was about the hypothesis testing (HT) procedure for the cases involving statistics the mean, the proportion, and the variance, of a sample. It covered two HT approaches: using the critical value and using the p-value. Specifically, the chapter had the objectives to enable the students to: (1) develop both one- and two-tailed null and alternative hypotheses that can be tested in a business setting by examining the rejection and non-rejection regions in light of Type I and Type II errors; (2) reach a statistical conclusion in hypothesis testing problems about a population mean with a known population standard deviation using a z statistic; (3) reach a statistical conclusion in hypothesis testing problems about a population mean with an unknown population standard deviation using the t-statistics; (4) reach a statistical conclusion in hypothesis testing problems about a population proportion using the z-statistic; (5) reach a statistical conclusion in hypothesis testing problems about a population variance using the chi-square statistic; and finally, (6) solve possible Type II errors when failing to reject the null hypothesis [18].

The teaching materials of Chapter 10 was also about HT but involving two populations. Similarly, it also covered the critical value and p-value approaches. The chapter had the objectives to enable the students to: (1) test hypotheses and develop confidence intervals about the difference in two means with known population variances using the z statistic; (2) test hypotheses and develop confidence intervals about the difference in two means of independent samples with unknown population variances using the t test; (3) test hypotheses and develop confidence intervals about the difference in two dependent populations; (4) test hypotheses and develop confidence intervals about the difference in two population proportions; and (5) test hypotheses about the difference in two population variances using the F distribution.

To achieve the above learning objectives, [18] imparted a standardized procedure called HTAB System of Testing Hypotheses. HTAB stands for Hypothesize, Test, Action, and Business. The HTAB procedure is reproduced in Fig. 2. Step 1 in Task 1 of the procedure is to establish the null and alternative hypotheses. To accomplish this step, the student should realize the characteristics of the two hypotheses. Our subject matter expert understood this need; thus, he highlighted the most important and relevant passages within the text to help the students zeroing in on the issue (see Fig. 1(c)).

The second task consists of Step 2 to Step 6. To succeed

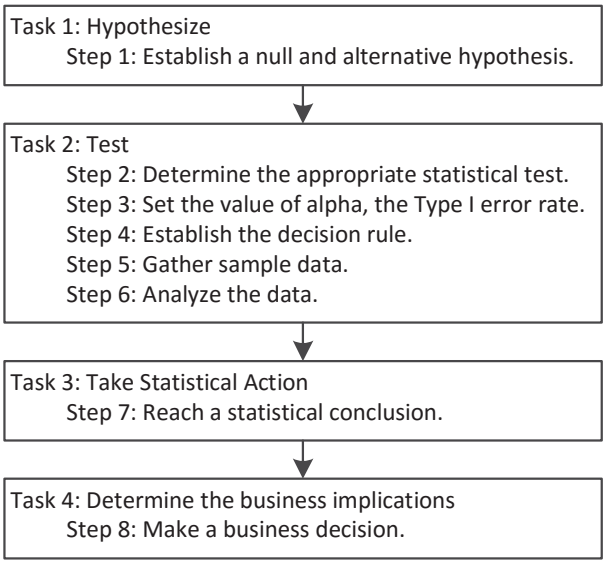


Fig. 2. The HTAB System of Testing Hypotheses imparted by [18] to standardize the procedure.

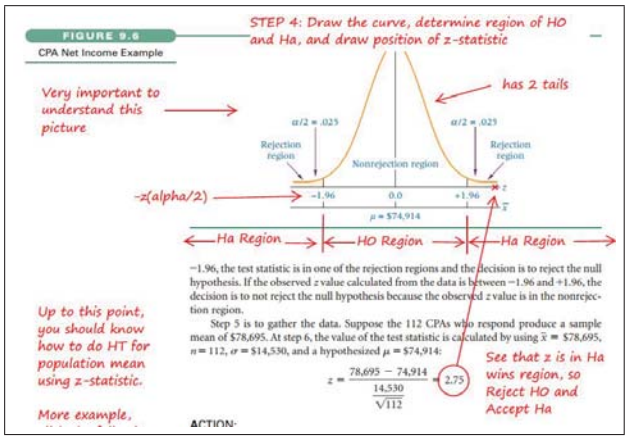


Fig. 3. The subject matter expert uses arrows and notes to connect ideas and to enrich the learning material.

with the task, the student should understand the probabilistic distribution of the statistic, the concepts of significance level α, the areas related to the null and alternative hypotheses within the curve, and how to compute the sample statistic. Our subject matter expert used arrows and notes to demonstrate and connects these concepts (see Fig. 3). For example, he circled the sample statistic obtained from the sample, $z = 2.75$, and utilized an arrow to point its location in the horizontal axis of the probability distribution curve. He had also divided the axis into three regions: two 'Ha region' and one 'H0 region.' Beside the value of the sample statistic, he added a note: "see that z is in Ha wins region, so reject H0 and accept Ha." This demonstrates how to subject matter expert uses arrows, notes, and picture to connect some ideas.

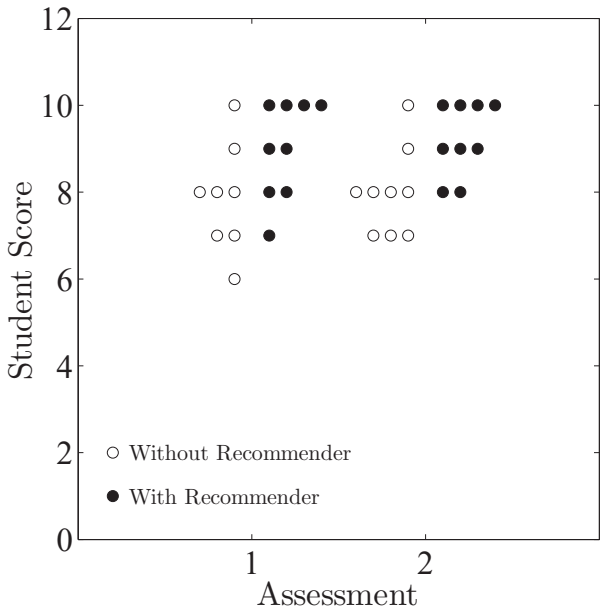


Fig. 4. The distributions of the student scores for the two assessments. The learning materials were Chapter 9 and Chapter 10 of [18]. Assessment 1 was related to the learning material of Chapter 9 and Assessment 2 was about Chapter 10. The maximum possible score is ten.

TABLE II
THE RESULTS OF THE WELCH'S t-TEST AND MANN-WHITNEY U TEST FOR TWO POPULATION MEANS—WITH AND WITHOUT RECOMMENDER SYSTEM—AT THE SIGNIFICANCE LEVEL $\alpha = 0.05$. A p-VALUE LOWER THAN α DENOTES THAT THERE ARE SIGNIFICANT DIFFERENCES BETWEEN THE TWO-POPULATION MEANS UNDER THE CONDITION SET BY THE NULL HYPOTHESIS.

	Assessment #1		Assessment #2	
	Without	With	Without	With
Mean	5.76	9.00	8.00	9.20
Variance	2.28	1.25	1.00	0.69
Welch's t-test				
df	15		15	
t Stat	−2.307		−2.817	
p-value	0.018		0.007	
t critical	−1.753		−1.753	
Mann-Whitney U Test				
Mean Rank	12.000	7.000	12.220	6.780
Sum of Ranks	108.000	63.000	110.000	61.000
Mann-Whitney U	18.000		16.000	
p-value	0.042		0.027	

TABLE III
THE EFFECT OF THE RECOMMENDATION SYSTEM ON THE STUDENT SCORES.

Study	Experimental			Control			Std. Mean Diff.
	Mean	SD	Total	Mean	SD	Total	Cohen's d (SD of d)
Chapter 9	9.00	1.118	9	7.56	1.510	9	2.439 (0.610)
Chapter 10	9.20	0.831	9	8.00	1.000	9	1.305 (0.515)

III. RESULTS AND DISCUSSION

The obtained student scores for the two given assessments are shown in Fig. 4. Although the number of data is rather limited due the difficulty of finding students having the acceptable level of language proficiency, the score distributions clearly show improvement of the student understanding of the learning material. Without the recommendation system, the score distribution tend to center around the score eight. The recommendation system shifts the center to the score ten.

The difference in the two population means are statistically evaluated using the Welch's t-test, Mann-Whitney U test, and the Cohen's d effect size index.

The results of the t and Mann-Whitney U tests are presented in Table II. The tests are performed at the significance level α of 5%. For the t-test, both assessments have the p-values of 0.018 and 0.007, which are significantly lower than the significance level. These results suggest that the learning recommendation significantly improves the student understanding. For the U-test, the p-values are 0.042 and 0.027, which are also lower than the significance level. For the effect size, the results are presented in Table III for the standardized mean difference Cohen's d index. According to [22], the effect should be considered very large, if the d values are higher than 1.20. On this basis, we consider that the recommendation system has a significant impact to the student understanding.

From the interviews with the participants after the assessment, we derived the following notes.

To all participants, learning the topic on the screen is hard. However, they do not consciously aware the aspects that make it hard. The richness of the textbook makes it more difficult.

The provided learning recommendation has helped them in various ways. It helped them to understand that the material on each chapter could be broken down according to the learning outcomes. Each time, they were aware that they only needed to concentrate on an outcome. Although the material was exhausted, the learning recommendation helped them to focus only on the essential aspects. Thus, they skimmed and skipped many parts of the material and spent more their time on the passages, which were marked important. They also utilized interactive objects to link concepts with formulas and examples. The participants perceived the provided annotates and highlights were essential to locate important sentences within the text such that they could easily bring their focus to those sentences. Furthermore, they could repeatedly read the sentences to understand better. The provided interactive objects were beneficial to understand the text organization and to locate the essential concepts quickly.

Clearly, this early study has demonstrated that the learning recommendation system, in forms of annotations, highlights, and interactive objects, provided by the subject expert are beneficial for learners. The object recommendations are used to highlight keywords and important concepts, to connect an idea with another, and to provide important comments that improve learner's understanding. We speculate that the current learning recommendation may be applicable, useful, and potentially has greater impacts in the context of the collaborative learning environment where each participant annotates and shares parts of the learning material he/she considers important.

IV. Conclusion

Reading on-screen has become a widely adopted reading modality with the proliferation of smartphones and tablet computers. The modality has been found to be not suitable for reading effortful materials such as textbooks. Reading on-screen has been found leading to spatial instability, difficulties in establishing mental map, and poor visual ergonomics due to the screen fresh-rate, contrast level, and fluctuating screen light. In this study, we evaluate to which extend a learning recommendation improving the quality of textbook learning on a computer screen. The learning recommendation is provided in term of marginal notes, highlights, annotations, hyperlinks, and interactive objects. The learning recommendation is designed to help student achieving learning outcomes of the materials. The empirical data of the scores of the assessment tests demonstrated that those students who used the recommendation system outperformed those without by more than 1.2 of the Cohen's d effect size index. This suggests that the recommendation system has a significant impact on improving the student understanding.

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